



**United Nations
Environment
Programme**

Distr.
GENERAL

UNEP/OzL.Pro/ExCom/84/47
26 November 2019

ORIGINAL: ENGLISH



EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Eighty-fourth Meeting
Montreal, 16–20 December 2019

PROJECT PROPOSAL: CUBA

This document consists of the comments and recommendations of the Secretariat on the following project proposal:

Refrigeration

- Conversion from the use of HFC-134a to propane (R-290) in the manufacture of chillers at Frioclima UNDP

PROJECT COVER SHEET

PROJECT TITLE

BILATERAL/IMPLEMENTING AGENCY

(a) Conversion from HFC-134a to R-290 (propane) in the manufacture of chillers at Frioclima	UNDP
---	------

NATIONAL CO-ORDINATING AGENCY

Cubaenergía – Oficina Técnica del Ozono

LATEST REPORTED CONSUMPTION DATA FOR ODS ADDRESSED IN PROJECT

A: ARTICLE-7 DATA (METRIC TONNES, 2018, AS OF JULY 2019)

HFCs	mt	N/A
	mt CO ₂ -eq.	N/A

B: COUNTRY PROGRAMME SECTORAL DATA (METRIC TONNES, 2018, AS OF JULY 2019)

HFCs	mt	N/A
	mt CO ₂ -eq.	N/A

HFC consumption remaining eligible for funding	mt	N/A
	mt CO ₂ -eq.	N/A

CURRENT YEAR BUSINESS PLAN ALLOCATIONS		Funding US \$	Phase-out (mt)
	(a)		0

PROJECT TITLE:		
HFC-134a used at enterprise:	mt	2.24
	mt CO ₂ -eq.	3,203
HFC-134a to be phased out through this project:	mt	2.24
	mt CO ₂ -eq.	3,203
Alternatives to be phased in:	mt	1.12
	mt CO ₂ -eq.	3.36
Project duration (months):		24
Initial amount requested (US \$):		175,300
Final project costs (US \$):		
Incremental capital cost:		115,000
Contingency:		5,000
Incremental operating cost:		0
Total project cost:		120,000
Local ownership (%):		100
Export component (%):		0
Requested grant (US \$):		120,000
Cost-effectiveness (US \$/kg) and (US \$/t CO ₂ -eq.)	US \$/kg	53.57
	US \$/mt CO ₂ -eq.	37.46
Implementing agency support cost (US \$):		10,800
Total cost of project to Multilateral Fund (US \$):		130,800
Status of counterpart funding (Y/N):		Yes
Project monitoring milestones included (Y/N):		Yes
SECRETARIAT'S RECOMMENDATION		For individual consideration

PROJECT DESCRIPTION

1. On behalf of the Government of Cuba, UNDP has submitted a project proposal to convert the manufacturing of chillers at Frioclima from HFC-134a to propane (R-290), at a total cost of US \$687,565 as originally submitted. The associated funding request from the Multilateral Fund amounts to US \$175,300, plus agency supporting costs of US \$12,271.

HFC consumption and enterprise background

2. Frioclima¹ is a 100 per cent locally-owned enterprise founded in 1992 that manufactures commercial air-cooled chillers in the capacity range of 60-100 tonnes of refrigeration² (RT), for commercial applications (e.g., supermarkets, shopping malls, hotels and other buildings), consisting of two to four independent cooling circuits. Frioclima also manufactured a small amount of water-cooled chillers. There is currently no production of residential air-conditioners in Cuba.

3. Until October 2016, Frioclima manufactured HCFC-22-based chillers; since then, the enterprise started manufacturing only HFC-134a-based chillers and, so far, has manufactured 52 chillers. Frioclima is able to manufacture 15 different types of chillers with charges ranging from 34 to 325 kg (48.6 to 464.7 mt CO₂-eq.) of HFC-134a; however, only three models have been manufactured, with an average charge of 40 kg (57.2 mt CO₂-eq) of HFC-134a per cooling circuit.

4. Frioclima has also an extended refrigeration service facility, separate from the manufacturing facility, that provides services to various types of refrigeration and air-conditioning (RAC) equipment operating in the country. The consumption of HFC-134a at Frioclima, used for manufacturing chillers and for servicing RAC equipment, is presented in Table 1.

Table 1. Consumption of HFC-134a at Frioclima

Consumption	2016	2017	2018	2019(*)
Metric tonnes				
Manufacturing	0.75	2.54	2.24	2.09
Servicing	5.44	7.38	6.62	6.17
Total (mt)	6.19	9.93	8.87	8.27
mt CO₂-eq.				
Manufacturing	1,070	3,636	3,209	2,994
Servicing	7,779	10,561	9,471	8,829
Total (mt CO₂-eq.)	8,849	14,197	12,680	11,823

(*) Up to June 2019.

5. The total consumption of HFC-134a used in the manufacturing of chillers from July 2018 to June 2019, was 3.22 mt (4,604 mt CO₂-eq), representing the impact of the project as submitted; the total consumption in 2019 has been estimated at 3.37 mt (4,820 mt CO₂-eq.).

Project description

6. The chiller manufacturing process at Frioclima consists of the following:

- (a) Local manufacturing of evaporator, condenser, and metal structures (including painting);

¹ Empresa Productora, Comercializadora y de Servicios de Postventa de Equipos de Climatización y Ventilación. It is the first enterprise in Cuba to obtain the ISO 9001 quality certificate.

² 1 tonne of refrigeration (RT) ≈ 3.51 kW.

- (b) Assembling of the main components (both locally manufactured and imported), electric parts, compressors and control systems; and
- (c) Refrigerant charging and performance testing of the equipment.

7. Frioclima, after assessing R-290 and HFOs as the most feasible alternative technologies for replacing HFC-134a, selected R-290 for the following reasons: it has a very low global-warming potential (GWP); it is currently available in the local market; its coefficient of performance (COP³) and energy efficiency ratio (EER) are higher than those for HFC-134a; and it requires approximately 50 per cent of the HFC-134a charge. Furthermore, the Government is planning to start locally producing approximately 40 mt of R-290 per year by the end of 2020.

8. Conversion to R-290 technology will entail:

- (a) *Redesign of the product:* Redesign of the two models (Chawt-1002 and Chawt-1402) with the largest manufacturing outputs; selection of suitable compressors and expansion valves; changes in the dimensioning of the evaporator, condenser, and piping due to lower refrigerant charge required; and safety components and controls. Redesign of other models will be based on the experience gained during the implementation of the project (at no additional cost to the Multilateral Fund); and
- (b) *Modifications to the plant:* Adjustments of equipment used to manufacture evaporators and condensers; installation of a central R-290 supply system, including refrigerant storage tanks outside the building and a stainless-steel supply line to feed the refrigerant storage tanks to the charging area; installation of a single-media R-290 charging machine; safety systems and enhanced ventilation; and replacement of R-290 leak detectors.

9. The conversion of the manufacturing line (including redesign of the product) will be completed in two years. However, the project proposes staged increase in the manufacturing of R-290-based chillers and staged decrease in the manufacturing of HFC-134a-based chillers over a five-year period, from the time plant modification would be completed.

Project costs

10. The total incremental capital costs (ICCs), as originally submitted, has been estimated at US \$339,200, of which US \$175,300 is being requested from the Multilateral Fund and US \$161,900 will be provided by the enterprise as co-financing, as shown in Table 2.

Table 2. ICCs for the conversion to R-290 at Frioclima (US \$)

Description	Total cost	Co-financing	Requested
Technical support			
Refrigeration expert	20,000		20,000
Product redesign	50,000	50,000	0
Building of prototypes (2xUS \$20,000)	40,000	20,000	20,000
Subtotal	110,000	70,000	40,000
New filling line			
Refrigerant supply system	12,000		12,000
Supply line, safety valves, accumulators	10,000		10,000
Refrigerant charging station	50,000		50,000
Installation services, including maintenance and training	18,000	9,000	9,000

³ COP of a refrigeration equipment is defined as the heat removed from the cold reservoir (i.e., inside a refrigeration equipment) divided by the work done to remove the heat (i.e., the work done by the compressor). Higher COPs equate to lower operating costs.

Description	Total cost	Co-financing	Requested
R-290 blow-off and vacuum station	15,000		15,000
Handheld leak detectors	2,000		2,000
Subtotal	107,000	9,000	98,000
Layout and safety			
Separation of charging area	10,000	10,000	0
High-capacity ventilation system	25,000		25,000
Related infrastructure work	20,000	20,000	0
Training of technicians	10,000	10,000	0
Product certification (2xUS \$5,000)	10,000	10,000	0
Final safety audit of R-290 installation	12,000	12,000	0
Machine modifications for adapted components	20,000	20,000	0
Subtotal	107,000	82,000	25,000
Subtotal ICC	324,000	161,000	163,000
Contingencies (10% of equipment cost)	15,200	900	12,300
Total ICC	339,200	161,900	175,300

11. The total incremental operating costs (IOCs) for one year have been estimated at US \$348,365, as shown in Table 3. However, IOCs will be fully funded by Frioclima as counterpart contribution.

Table 3. IOCs for the conversion to R-290 at Frioclima (US \$)

Description	HFC-134a	R-290	Difference
IOC due to refrigerant			
Price of refrigerant (US \$/kg)	6.50	14.60	
Refrigerant charge per unit (kg)	146	73	
IOC due to refrigerant	949	1,066	117
IOC due to components			
Compressor (2 per unit)	17,200	20,400	3,200
Three gas detectors	0	2,020	2,020
Light signals (2 per unit)	0	86	86
ATEX ⁴ control panel	0	3,000	3,000
ATEX certified ventilators (6 per unit)	5,658	15,570	9,912
IOC due to components			18,218
IOC per unit			18,335
Average units manufactured (July 2018-June 2019)			19
Total IOC			348,365

12. The total cost of the project amounts to US \$687,565, for the phase-out of 3.22 mt (4,604 mt CO₂-eq.) of HFC-134a, with a cost effectiveness of US \$213.53/kg (US \$149.34/mt CO₂-eq.). However, after deducting the counterpart funding by Frioclima, the cost-effectiveness would be US \$54.44/kg (US \$38.08/mt CO₂-eq.) for the Multilateral Fund.

13. In addition to the phase-out of 3.22 mt (4,604 mt CO₂-eq.) of HFC-134a, it is expected that the project will generate additional reductions of indirect emissions of CO₂ to the atmosphere, as the new equipment will be approximately 10 per cent more energy efficient than the HFC-134a-based models.

14. The project will be implemented in no more than 24 months.

⁴ Certification of equipment intended for use in potentially explosive atmospheres in the European Union.

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

15. The Secretariat has reviewed the project proposal on the basis of the current policies and decisions (in particular decision 81/53(b)),⁵ and other approved projects for the conversion from CFCs, HCFCs or HFCs to flammable refrigerants. The conversion of chillers has not been covered by previously approved projects pursuant to decisions 78/3(g) and 79/45.

16. Given the limited experience in the Fund with the conversion of chiller manufacturing enterprises, the Secretariat sought advice from a technical expert in reviewing the proposal.

Eligibility

17. The Government of Cuba ratified the Kigali Amendment on 20 June 2019. The project for Frioclima has been submitted in line with decisions 78/3(g) and 79/45 and includes an official letter from the Government indicating that, in the event that the project is approved, any reduction of HFC-134a consumption will be deducted from the starting point for aggregate HFC reductions that may be agreed in the future.

Maturity of the technology, replicability, and sustainability of the project

18. The Secretariat raised concerns about: the maturity of the R-290 technology in chillers in Cuba; its limited replicability in the other countries; the poor cost-effectiveness of the conversion (i.e., US \$213.53/kg (US \$149.34/mt CO₂-eq.) based on the total cost of the project); and the staged phase-out of HFC-134a over a five-year period.

19. UNDP reaffirmed that the use of R-290 in chillers is a mature technology that has been implemented on a larger scale, especially in Europe and in some Article 5 countries in Latin America. Co-financing from the European Union that has already been secured, will provide for technical assistance to facilitate the uptake of the technology in the local market, to adopt standards and to update regulatory measures as required. In 2020, Cuba will start the procedures for the adoption of the ISO 5149 standard.⁶

20. While consumption of HFC-134a in chillers is not high as compared to other applications, their large refrigerant charge per unit and the different process followed to charge the refrigerant as compared to other large refrigerant equipment, would be of relevance to several Article 5 countries.

21. UNDP also confirmed that the chiller manufacture line will be fully converted, prototypes will be developed and production of R-290-based chillers will start within the two-year period. The project will provide detailed information on the ICC and IOC during the proposed timeframe of two years, thereby complying with the requirements under decision 78/3(g). A five-year transition period is being requested to facilitate the market uptake of the R-290 technology, taking into account similar experiences in other Article 5 countries which converted from HCFC-22-based equipment to R-290.

22. While the Secretariat recognized that some enterprises that successfully converted their manufacturing lines to R-290 technologies have not been able to introduce the converted equipment into the market, the five-year transition period being requested was too high. After further discussion, it was

⁵ Bilateral and implementing agencies were invited to submit project proposals for conversion to alternatives to HFCs and the promotion of new technologies, especially in sectors and regions that had not been covered by approved investment projects.

⁶ Specifies the requirements for the safety of persons and property, provides guidance for the protection of the environment, and establishes procedures for the operation, maintenance, and repair of refrigerating systems and the recovery of refrigerants.

agreed to reduce it to three years, noting that Frioclima has a commitment that it will not revert to producing HFC-134a (or other high-GWP)-based equipment. Given the relevance of the information related to the market uptake of the R-290-based chiller during the three-year transition period, it was agreed that UNDP would submit two reports providing information on the market uptake of the R-290-based chillers including challenges, and the status of the staged reduction on the manufacturing of HFC-134a chillers, one year and a half and three years after completion of the conversion.

23. The Secretariat questioned the long-term sustainability of the project, noting the very high operating costs of US \$18,355 per R-290 chiller produced, making it economically unviable in comparison to the HFC-134a-based chiller currently offered on the local market. In responding, UNDP explained that the improved energy efficiency and better performance of the R-290 chiller is expected to offset the increased operating costs within a period of approximately one year, assuming that the chiller will be continuously operating during 365 days and the cost of electricity of US \$0.20/kW-hour. The Secretariat notes that this is a preliminary estimation that would need to be thoroughly assessed on the converted R-290 chillers; furthermore, this information would be fundamental for Frioclima to determine the efficiency of the new chiller in terms of electricity use as compared to the HFC-134a chiller, and the pay-back period for the higher investment by the end-user, which will also ascertain the long-term sustainability of the conversion.

24. In view of the above, the Secretariat proposed that during the three-year transition period after the conversion of the project has been completed, an annual report should be submitted providing a comparison of the energy efficiency and the actual electricity consumption of the new R-290 chiller and the HFC-134a chiller. In addressing this request, UNDP proposed the submission of one (rather than three) report, and agreed to calculate the energy efficiency of the R-290 chiller in relation to the HFC-134a chiller; however, it could not commit to provide a comparison analysis on electricity consumption of the two different chillers by the end-user. The Secretariat considers that without this information the demonstration project is less attractive as it would not provide information on whether conversion to R-290 in chillers would be economically sustainable and replicable. The Secretariat also notes that several demonstration projects funded by the Multilateral Fund (e.g., Argentina, Turkey) have provided actual measurements in the use of electricity between the equipment in the baseline and the converted equipment.

25. In line with decision 22/38 and subsequent decisions of the Executive Committee, UNDP confirmed that equipment to be replaced by the project will be destroyed or rendered unusable, and will be recorded in the project completion report.

Issues on incremental capital costs

26. The Secretariat questioned the eligibility of the installation of a new supply system (including refrigerant tanks, a supply line to feed the refrigerant tanks to the charging area), and the new automatic refrigerant charging unit, as these equipment is not in the baseline. Currently, HFC-134a is directly charged into the chiller from the refrigerant cylinder with manifolds and a scale, at the production line. In addressing this issue, UNDP confirmed the current charging operation as explained above; however, given the flammability of R-290, a supply system, with tanks, a pump and a pipe line to feed the charging unit, has to be installed outside the building. The automatic charging station will secure interruption of the charging process in case of leaks, blockage of the charging process in case the chiller is not sufficiently evacuated, and the accurate refrigerant charged. In further discussions, and taking into account the production output of the enterprise (i.e., less than 20 chillers per year), and safety and security aspects, it was agreed to include the new supply system (i.e., refrigerant storage tanks, a pumps and a supply line to feed the refrigerant tanks to the charging area), and deduct funding equivalent to the cost of the automatic charging unit, as refrigerant charging could be safely done by minimizing the amount of refrigerant cylinders inside the production line, and installing enhanced ventilation. This resulted on a cost adjustment US \$98,000 to US \$50,000, on the understanding that UNDP would have flexibility to reallocate funds within the agreed ICC in case that the refrigerant filling system was more expensive than US \$50,000. It was also agreed to include as part of the

final report on ICC and IOC the selected methodology used to charge R-290 in the chiller and associated costs.

27. Although IOCs will be completely provided as counterpart funding by Frioclima, the Secretariat noted that the main items that account for the majority of these costs are the compressor, the ventilators and the control panel (each at an approximately US \$3,000); it also noted that savings on materials associated with the reduced tube diameter of the heat exchangers were not accounted for in the calculations. Notwithstanding that IOCs are not requested from the Fund, UNDP confirmed that the final report will provide a comprehensive analysis of these costs, in line with decision 78/3(g).

28. In line with existing policies and guidelines, it was agreed that the reference consumption for the project phase out be the last calendar year consumption (2.24 mt (3,203 mt CO₂-eq) in 2018) rather than the initially proposed consumption between July 2018 and June 2019.

29. At the conclusion of the project review, the eligible incremental costs for the conversion of chiller manufacturing at Frioclima has been agreed at US \$120,000, to phase out a total of 2.24 mt (3,203 mt CO₂-eq.) of HFC-134a, at a cost effectiveness of 53.57 US \$/kg (37.46 US \$/mt CO₂-eq) as shown in Table 4.

Table 4. Revised agreed costs for the conversion of chillers manufacturing at Frioclima (US \$)

Description	Requested	Co-financing
Technical support		
Refrigeration expert	20,000	
Product redesign	0	50,000
Building of prototypes (2xUS \$20,000))	20,000	20,000
Subtotal	40,000	70,000
New filling line		
Refrigerant supply system	50,000	
Supply line, safety valves, accumulators		
Refrigerant charging station		
Installation services, including maintenance and operator training		9,000
HC blow-off and vac station		
Handheld leak detectors		
Subtotal	50,000	9,000
Layout and safety		
Separation of charging area	0	10,000
High-capacity ventilation system	25,000	
Related infrastructure work	0	20,000
Training of service team	0	10,000
Product certification (2xUS \$5,000)	0	10,000
Final safety audit of R-290 installation	0	12,000
Machine modifications for adapted components	0	20,000
Subtotal	25,000	82,000
Subtotal	115,000	161,000
Contingency (10% of equipment cost)	5,000	900
Total cost	120,000	161,900

30. The Secretariat notes that the purpose of implementing projects under decision 78/3(g) is to gain experience in the ICCs and IOCs that might be associated with phasing down HFCs. On the basis of the information available at the time of review, the Secretariat considers that the agreed costs are its best estimates of the overall incremental costs of conversion; these estimates, however, might change as more information becomes available and according to the specific characteristics of the enterprises. The Secretariat, therefore, considers that approval of the project at the levels proposed above would not constitute a precedent.

Co-funding

31. Noting that more than 70 per cent (US \$510,265) of the cost would be co-funded, and upon a request by the Secretariat, UNDP provided a letter from Frioclima committing to provide the co-funding which is already available as there are additional initiatives associated with the adoption of R-290 technology in the enterprise. UNDP also indicated that Cuba is participating in the sustainable and climate-friendly phase-out of ODS initiative funded by the European Union,⁷ which has allocated approximately US \$100,000 to Frioclima to convert to R-290.

2019–2021 business plan

32. The Secretariat notes that this project was not included in the 2019–2021 business plan of the Multilateral Fund.

Conclusion

33. After extensively weighed the merits of the demonstration project in the light of relevant decisions on demonstration projects; the knowledge that could be acquired from the comprehensive review of the ICC and IOC that will be incurred; the potential replicability of the technology and/or the conversion of the manufacturing line in other Article 5 countries; and the knowledge on actual improvements on energy efficiency associated with the change of technology, the Secretariat decided to submit it for consideration by the Executive Committee.

34. The Secretariat and UNDP had reach and agreement on all policy and costs items of the project, except for a report comparing the actual consumption of electricity between the HFC-134a chiller and the R-290-based chiller, which in the views of the Secretariat is highly relevant (as reflected in the recommendation).

RECOMMENDATION

35. The Executive Committee may wish:

- (a) To consider the project proposal for the conversion of air-cooled chillers manufacturing from the use of HFC-134a to propane (R-290) at Frioclima;
- (b) To further consider on whether or not to approve the project indicated in sub-paragraph (a) above in the amount of US \$120,000, plus agency support costs of US \$10,800 for UNDP, on the understanding, if the project were to be approved:
 - (i) That 2.24 mt (3,203 mt CO₂-eq.) of HFC-134a would be deducted from the starting point for sustained aggregate reduction in HFC once it had been established;
 - (ii) That the conversion would be completed within 24 months of the transfer of funds to UNDP, that any remaining funds would be returned to the Multilateral Fund no later than one year after the date of project completion and that a comprehensive completion report would be submitted within six months of project completion with detailed information on:

⁷ Implemented through Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and UNDP.

- a. The eligible incremental capital costs for all equipment and other components required for the conversion of the manufacturing line, including those not funded under the project;
 - b. Incremental operating costs, including detailed information on the price of refrigerants, compressors, electric panel, ventilators and other items, noting these costs will be fully covered by the enterprise;
 - c. Any potential savings that could be incurred during the conversion, in particular savings on materials associated with the reduced tube diameter of the heat exchangers, and other relevant factors that facilitated implementation (e.g. whether any purchased and/or installed equipment or supplies had gone through a competitive quote/bidding process and the details thereof); and
 - d. Changes in the energy efficiency of the products being manufactured and any related policies established by the Government;
- (iii) That UNDP would submit to the Executive Committee:
- a. A report on the measurement of improved energy efficiency of the R-290 chiller with regard to the HFC-134a chiller in Cuba, [including the electricity consumption,] one year after completion of the conversion;
 - b. A report providing information on the market uptake of the R-290 chillers including challenges, and the status of the staged reduction on the manufacturing of HFC-134a chillers, one year and a half and three years after completion of the conversion; and
- (c) That the enterprise Frioclima commits not to revert to the use of HFC-134a in manufacturing after completion of the project, and will undertake efforts to stop manufacturing HFC-134a chillers in less than five years after the project proposal referred to in sub-paragraph (a) above has been approved.
-